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AN ADAPTATION OF THE MINIMUF HF PROPAGATION PREDICTION PROGRAM TO THE TI-59 CALCULATOR

Jay H. Benson
Stephen Jauregui, Jr.

Final Report for period April 1980 - July 1980

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Prepared for: Naval Electronic Systems Command
(PME-107-6)
Washington, DC 20360

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
NPS-62-80-017PR

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (*and Subtitle*)
AN ADAPTATION OF THE MINIMUF HF PROPAGATION PREDICTION PROGRAM TO THE TI-59 CALCULATOR

5. TYPE OF REPORT & PERIOD COVERED
Final Report April-July 1980

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(*s*)
Jay H. Benson
Stephen Jauregui, Jr.

8. CONTRACT OR GRANT NUMBER(*s*)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Electronic Systems Command (PME-107-6)
Washington, DC 20360

12. REPORT DATE
1 July 1980

13. NUMBER OF PAGES
27

14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*)

15. SECURITY CLASS. (*of this report*)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

MINIMUF
HF PROPAGATION PREDICTION
MAXIMUM USABLE FREQUENCY

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

An algorithm for predicting the Maximum Usable Frequency between two points on the surface of the earth for High Frequency communications is implemented on a TI-59 hand-held programmable calculator.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601 |

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SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

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ABSTRACT

An algorithm for predicting the Maximum Usable Frequency between two points on the surface of the earth for High Frequency communications is implemented on a TI-59 hand-held programmable calculator.

1. INTRODUCTION

An algorithm for predicting the Maximum Usable Frequency (MUF) in the High Frequency radio band has been developed at the Naval Ocean Systems Center, San Diego, California, by R.B. Rose and J.N. Martin [1], and has been implemented in both FORTRAN IV and BASIC computer languages under the name MINIMUF-3.5. The algorithm has been incorporated into the CLASSIC PROPHET propagation analysis system, and has been demonstrated to provide a field-deployable capability for computing HF propagation paths with micro-computer resources.

2. OBJECTIVE

The essential portions of MINIMUF-3.5 are contained in approximately 80 BASIC language statements, reproduced in appendix A, which suggests a potential for being encoded in hand-held programmable calculators. H.F. Hite of Hughes Aircraft Company adapted a restricted version of MINIMUF-3.0 for the HP-67 calculator that computes MUFs for 1-hop F-layer propagation and is thus limited to station separations of 4000 kilometers or less. A complete implementation of MINIMUF, capable of 2-hop path prediction, was desired.

3. PROGRAM DEVELOPMENT

A TI-59 calculator program was adapted directly from the Rose and Martin BASIC program listing with some logic changes required to accomodate the memory constraints of the calculator. The program listing, summary of logic changes, operating instructions, and test case are contained in appendices B, C, D, and E, respectively. The program listing is annotated with cross-references to statements in the BASIC listing for assistance in tracing logic flow. The bulk of the development task was to minimize program and data storage requirements. Several iterations finally produced the current version which requires 800 program steps and 20 data registers, the full capacity of the normally-accessible calculator attributes.

4. PERFORMANCE

The TI-59 program was optimized for storage, that being the overriding constraint. Execution time for single-hop predictions is approximately 50 seconds. Were the program optimized for speed, given a larger storage capacity, execution time could conceivably approach 40 seconds. The test case contained in appendix E is the identical test case promulgated with the Rose and Martin report, and yields the same results on the TI-59. Notice, however, that the MUF limit of 32 MHz has been raised to 50 MHz, thereby providing for HF path prediction during periods of high solar flux when customary band limitations are exceeded. The test case should be executed after initially programming the TI-59 by keystroke to ensure correct program entry. A copy of the program is available on magnetic cards by sending two blank cards to the authors, however, the user is cautioned that magnetic cards are not guaranteed to be transportable among all TI-59 calculators.

5. CONCLUSIONS AND RECOMMENDATIONS

A capability for predicting Maximum Usable Frequencies in the HF radio band can be realized with hand-held calculators, and therefore can be widely deployed in the field. An even larger capability can be realized by utilizing custom made modules for the TI-59. Each module provides for 5000 program steps in addition to the normal 960 maximum step capacity of the calculator, and could provide for additional portions of the CLASSIC PROPHET System to be included in calculator implementations, such as the D-region absorption model. Appendix F lists several persons to contact in regard to having custom modules manufactured for the TI-59.

APPENDIX A

BASIC MINIMUF-3.5 PROGRAM LISTING

The BASIC language listing of MINIMUF-3.5 is reprinted here with the permission of R.B. Rose, and serves as a guide for the TI-59 keystroke listing.

```
1000 REM
1010 K7=SIN(L1)*SIN(L2)+COS(L1)*COS(L2)*COS(W2-W1)
1020 G1=ACS(K7 MAX -1+1.0E-5 MIN 1-1.0E-8)
1030 K6=1.59*G1
1040 K6=K6 MAX 1
1050 K5=1/K6
1060 J9=100
1070 FOR K1=1/(2*K6) TO 1-1/(2*K6) STEP 0.9999-1/K6
1080 IF K5=1 THEN 1100
1090 K5=0.5
1100 P=SIN(L2)
1110 Q=COS(L2)
1120 A=(SIN(L1)-P*COS(G1))/(Q*SIN(G1))
1130 B=G1*K1
1140 C=P*COS(B)+Q*SIN(B)*A
1150 D=(COS(B)-C*P)/(Q*SQR(1-C*C))
1160 D=ACS(D MAX -1+1.0E-5 MIN 1-1.0E-8)
1170 W0=W2+SGN(SIN(W1-W2))*D
1180 IF W0=>0 THEN 1200
1190 W0=W0+P1
1200 IF W0<P1 THEN 1220
1210 W0=W0-P1
1220 L0=P0-ACS(C MAX -1+1.0E-5 MIN 1-1.0E-8)
1230 Y1=0.0172*(10+(M0-1)*30.4+D6)
1240 Y2=0.409*COS(Y1)
1250 K8=3.82*W0+12+0.13*(SIN(Y1)+1.2*SIN(2*Y1))
1260 K8=K8-12*(1+SGN(K8-24))*SGN(ABS(K8-24))
1270 IF COS(L0+Y2)>-0.26 THEN 1350
1280 K9=0
1290 G0=0
1300 M9=2.5*G1*K5
1310 M9=M9 MIN P0
1320 M9=SIN(M9)
1330 M9=1+2.5*M9*SQR(M9)
1340 GO TO 1590
1350 K9=(-0.26+SIN(Y2)*SIN(L0))/(COS(Y2)*COS(L0)+1.0E-3)
1360 K9=12-ATN(K9/SQR(ABS(1-K9*K9)))*7.639437
1370 T=K8-K9/2+12*(1-SGN(K8-K9/2))*SGN(ABS(K8-K9/2))
1380 T4=K8+K9/2-12*(1+SGN(K8+K9/2-24))*SGN(ABS(K8+K9/2-24))
```

```
1390 C0=ABS(COS(L0+Y2))
1400 T9=9.7*C0↑9.6
1410 IF T9>0.1 THEN 1430
1420 T9=0.1
1430 M9=2.5*G1*K5
1440 M9=M9 MIN P0
1450 M9=SIN(M9)
1460 M9=1+2.5*M9*SQR(M9)
1470 IF T4<T THEN 1500
1480 IF (T5-T)*(T4-T5)>0 THEN 1510
1490 GO TO 1640
1500 IF (T5-T4)*(T-T5)>0 THEN 1640
1510 T6=T5+12*(1+SGN(T-T5))*SGN(ABS(T-T5))
1520 G9=PI*(T6-T)/K9
1530 G8=PI*T9/K9
1540 U=(T-T6)/T9
1550 G0=C0*(SIN(G9)+G8*(EXP(U)-COS(G9)))/(1+G8*G8)
1560 G7=C0*(G8*(EXP(-K9/T9)+1))*EXP((K9-24)/2)/(1+G8*G8)
1570 IF G0=>G7 THEN 1590
1580 G0=G7
1590 G2=(1+S9/250)*M9*SQR(6+58*SQR(G0))
1600 G2=G2*(1-0.1*EXP((K9-24)/3))
1610 G2=G2*(1+(1-SGN(L1)*SGN(L2))*0.1)
1620 G2=G2*(1-0.1*(1+SGN(ABS(SIN(L0))-COS(L0))))
1630 GO TO 1700
1640 T6=T5+12*(1+SGN(T4-T5))*SGN(ABS(T4-T5))
1650 G8=PI*T9/K9
1660 U=(T4-T6)/2
1670 U1=-K9/T9
1680 G0=C0*(G8*(EXP(U1)+1))*EXP(U)/(1+G8*G8)
1690 GO TO 1590
1700 IF G2>J9 THEN 1720
1710 J9=G2
1720 NEXT K1
1730 J9=J9 MAX 2 MIN 32
1740 RETURN
```

APPENDIX B

TI-59 PROGRAM LISTING

The keystroke listing of the TI-59 program implementation of MINIMUF-3.5 follows. Segments of TI-59 code are cross-referenced to the BASIC program listing.

```
000  76  LBL
001  11   A
002  42  STO
003  18   18
004  99  PRT
005  25  CLR
006  60  DEG   1010,20
007  43  RCL
008  15   15
009  75   -
010  43  RCL
011  13   13
012  95   =
013  39  COS
014  65   ×
015  43  RCL
016  12   12
017  39  COS
018  65   ×
019  43  RCL
020  14   14
021  39  COS
022  85   +
023  43  RCL
024  12   12
025  38  SIN
026  65   ×
027  43  RCL
028  14   14
029  38  SIN
030  95   =
031  70  RAD
032  22  INV
033  39  COS
034  42  STO
035  06   06
036  65   ×    1030,40,50
037  01   1
038  93   .
039  05   5
040  09   9
041  95   =
042  32  X:T
043  01   1
044  71  SBR
045  07   07
046  95   95
047  35  1/X
048  42  STO
049  07   07
```

```
050  32  X:T   1080,90
051  01   1
052  67   EQ
053  00   00
054  57   57
055  93   .
056  05   5
057  65   ×    1300,10,20,30
058  43  RCL
059  06   06
060  65   ×
061  05   5
062  95   =
063  32  X:T
064  89   π
065  71  SBR
066  07   07
067  94   94
068  55   ÷
069  02   2
070  95   =
071  38  SIN
072  45  YX
073  01   1
074  93   .
075  05   5
076  65   ×
077  02   2
078  93   .
079  05   5
080  85   +
081  01   1
082  95   =
083  42  STO
084  08   08
085  01   1    1060
086  00   0
087  00   0
088  42  STO
089  11   11
090  02   2    1070
091  75   -
092  43  RCL
093  07   07
094  59  INT
095  95   =
096  42  STO
097  09   09
098  01   1    1070 - cont'd
099  75   -
```

```
100   43  RCL
101   07   07
102   95    =
103   65    ×
104   53    (
105   43  RCL
106   09   09
107   75    -
108   01    1
109   54    )
110   85    +
111   43  RCL
112   07   07
113   55    ÷
114   02    2
115   95    =
116   65    ×        1130
117   43  RCL
118   06   06
119   95    =
120   42  STO
121   00   00
122   43  RCL        1100,10,20
123   14   14
124   60  DEG
125   39  COS
126   42  STO
127   01   01
128   35  1/X
129   65    ×
130   53    (
131   43  RCL
132   12   12
133   38  SIN
134   75    -
135   43  RCL
136   14   14
137   38  SIN
138   42  STO
139   02   02
140   65    ×
141   43  RCL
142   06   06
143   70  RAD
144   39  COS
145   95    =
146   55    ÷
147   43  RCL
148   06   06
149   38  SIN
```

```
150   65    ×        1140
151   43  RCL
152   00   00
153   38  SIN
154   65    ×
155   43  RCL
156   01   01
157   85    +
158   43  RCL
159   02   02
160   65    ×
161   43  RCL
162   00   00
163   39  COS
164   95    =
165   42  STO
166   03   03
167   22  INV        1220
168   39  COS
169   94  +/-
170   85    +
171   89    π
172   55    ÷
173   02    2
174   95    =
175   42  STO
176   10   10
177   43  RCL        1150
178   00   00
179   39  COS
180   75    -
181   43  RCL
182   03   03
183   65    ×
184   43  RCL
185   02   02
186   95    =
187   55    ÷
188   43  RCL
189   01   01
190   75    -
191   53    (
192   01    1
193   75    -
194   43  RCL
195   03   03
196   33   X²
197   54    )
198   34   ΓX
199   95    =
200  22 INV    1160,70,80,90,1200,10
201  39 COS
202  65  ×
203  53  (
204  43 RCL
205  13  13
206  75  -
207  43 RCL
208  15  15
209  54  )
210  60 DEG
211  38 SIN
212  69 OP
213  10  10
214  85  +
215  43 RCL
216  15  15
217  65  ×
218  89  π
219  55  ÷
220  01  1
221  08  8
222  00  0
223  95  =
224  32 X:T
225  89  π
226  65  ×
227  02  2
228  85  +
229  32 X:T
230  95  =
231  22 INV
232  77  GE
233  02  02
234  38  38
235  75  -
236  32 X:T
237  95  =
238  32 X:T
239  93  .      1230
240  00  0
241  01  1
242  07  7
243  02  2
244  65  ×
245  53  (
246  01  1
247  00  0
248  85  +
249  43 RCL
```

```
250  17  17
251  85  +
252  03  3
253  00  0
254  93  .
255  04  4
256  65  ×
257  53  (
258  43 RCL
259  16  16
260  75  -
261  01  1
262  95  =
263  42 STO
264  00  00
265  70 RAD    1240
266  39 COS
267  65  ×
268  93  .
269  04  4
270  00  0
271  09  9
272  95  =
273  42 STO
274  01  01
275  32 X:T    1250
276  65  ×
277  03  3
278  93  .
279  08  8
280  02  2
281  85  +
282  01  1
283  02  2
284  85  +
285  93  .
286  01  1
287  03  3
288  65  ×
289  53  (
290  43 RCL
291  00  00
292  38 SIN
293  85  +
294  01  1
295  93  .
296  02  2
297  65  ×
298  53  (
299  43 RCL
```

```
300   00   00
301   65    ×
302   02    2
303   54    )
304   38  SIN
305   95    =
306   75    -     1260
307   32  X:T
308   02    2
309   04    4
310   95    =
311   32  X:T
312   75    -
313   01    1
314   02    2
315   65    ×
316   53    (
317   01    1
318   85    +
319   32  X:T
320   69  OP
321   10   10
322   42  STO
323   00   00
324   54    )
325   65    ×
326   43  RCL
327   00   00
328   50  I×I
329   95    =
330   42  STO
331   00   00
332   93    .     1270
333   02    2
334   06    6
335   94  +/-
336   32  X:T
337   43  RCL
338   01   01
339   85    +
340   43  RCL
341   10   10
342   95    =
343   39  COS
344   42  STO
345   02   02
346   77   GE
347   04   04
348   60   60
349   00    0   1280,90

350   42  STO
351   03   03
352   34  √X    1590
353   65    ×
354   05    5
355   08    8
356   85    +
357   06    6
358   95    =
359   34  √X
360   65    ×
361   43  RCL
362   08   08
363   65    ×
364   53    (
365   01    1
366   85    +
367   43  RCL
368   19   19
369   55    ÷
370   02    2
371   05    5
372   00    0
373   95    =
374   65    ×     1600
375   53    (
376   01    1
377   75    -
378   93    .
379   01    1
380   65    ×
381   53    (
382   43  RCL
383   03   03
384   55    ÷
385   03    3
386   75    -
387   08    8
388   54    )
389   22  INV
390   23  LNX
391   95    =
392   65    ×     1610
393   53    (
394   01    1
395   85    +
396   93    .
397   01    1
398   65    ×
399   53    (
400   01    1
401   75    -
402   53    (
403   43  RCL
404   12   12
405   65    ×
406   43  RCL
407   14   14
408   54    )
409   69  OP
410   10   10
411   95    =
412   65    ×     1620
413   53    (
414   01    1
415   75    -
416   93    .
417   01    1
418   65    ×
419   53    (
420   01    1
421   85    +
422   53    (
423   43  RCL
424   10   10
425   38  SIN
426   50  I×I
427   75    -
428   43  RCL
429   10   10
430   39  COS
401   54    )
402   69  OP
433   10   10
434   95    =
435   32  X:T
436   43  RCL   1700
437   11   11
438   71  SBR
439   07   07
440   94   94
441   42  STO
442   11   11
443   97  DSZ   1070,1720
444   09   09
445   00   00
446   98   98
447   32  X:T   1730,40
448   02    2
449   71  SBR
```

```
450   07   07
451   95   95
452   32  X:T
453   05    5
454   00    0
455   71  SBR
456   07   07
457   94   94
458   99  PRT
459   91  R/S
460   93    .     1350,60
461   02    2
462   06    6
463   94  +/-
464   85    +
465   43  RCL
466   01   01
467   38  SIN
468   65    ×
469   43  RCL
470   10   10
471   38  SIN
472   95    =
473   55    ÷
474   53    (
475   43  RCL
476   01   01
477   39  COS
478   65    ×
479   43  RCL
480   10   10
481   39  COS
482   85    +
483   93    .
484   00    0
485   00    0
486   01    1
487   95    =
488   22  INV
489   38  SIN
490   65    ×
491   07    7
492   93    .
493   06    6
494   04    4
495   94  +/-
496   85    +
497   01    1
498   02    2
499   95    =
500   42  STO
501   03   03
502   43  RCL    1370
503   00   00
504   75   -
505   43  RCL
506   03   03
507   55   ÷
508   02   2
509   95   =
510   85   +
511   32  X:T
512   01   1
513   02   2
514   65   ×
515   53   (
516   32  X:T
517   69  OP
518   10   10
519   94  +/-
520   85   +
521   32  X:T
522   01   1
523   54   )
524   65   ×
525   32  X:T
526   50  I×I
527   95   =
528   42  STO
529   04   04
530   43  RCL    1380
531   00   00
532   85   +
533   43  RCL
534   03   03
535   55   ÷
536   02   2
537   75   -
538   32  X:T
539   02   2
540   04   4
541   95   =
542   32  X:T
543   75   -
544   01   1
545   02   2
546   65   ×
547   53   (
548   32  X:T
549   69  OP
```

```
550   10   10
551   85   +
552   32  X:T
553   01   1
554   54   )
555   65   ×
556   32  X:T
557   50  I×I
558   95   =
559   42  STO
560   05   05
561   43  RCL    1390,1400,10,20
562   02   02
563   50  I×I
564   42  STO
565   00   00
566   45  Y×
567   09   9
568   93   .
569   06   6
570   65   ×
571   09   9
572   93   .
573   07   7
574   95   =
575   32  X:T
576   93   .
577   01   1
578   71  SBR
579   07   07
580   95   95
581   42  STO
582   01   01
583   65   ×      1530,1650
584   89   π
585   55   ÷
586   43  RCL
587   03   03
588   95   =
589   42  STO
590   02   02
591   43  RCL    1470
592   04   04
593   75   -
594   43  RCL
595   05   05
596   95   =
597   69  OP
598   10   10
599   65   ×
```

```
600  53   (
601  43  RCL
602  18   18
603  75   -
604  43  RCL
605  04   04
606  54   )
607  65   ×
608  53   (
609  43  RCL
610  05   05
611  75   -
612  43  RCL
613  18   18
614  54   )
615  95   =
616  32  X:T
617  00   0
618  22  INV
619  77   GE
620  07   07
621  35   35
622  43  RCL     1510
623  18   18
624  85   +
625  01   1
626  02   2
627  65   ×
628  53   (
629  53   (
630  43  RCL
631  04   04
632  75   -
633  43  RCL
634  18   18
635  54   )
636  69  OP
637  10   10
638  85   +
639  32  X:T
640  01   1
641  54   )
642  65   ×
643  32  X:T
644  50  I×I
645  75   -      1520
646  43  RCL
647  04   04
648  95   =
649  65   ×
```

```
650  32  X:T
651  89   π
652  55   ÷
653  43  RCL
654  03   03
655  95   =
656  42  STO
657  05   05
658  32  X:T     1550
659  94  +/-
660  55   ÷
661  43  RCL
662  01   01
663  95   =
664  22  INV
665  23  LNX
666  75   -
667  32  X:T
668  39  COS
669  95   =
670  65   ×
671  43  RCL
672  02   02
673  85   +
674  43  RCL
675  05   05
676  38  SIN
677  95   =
678  65   ×
679  43  RCL
680  00   00
681  55   ÷
682  53   (
683  01   1
684  85   +
685  43  RCL
686  02   02
687  33  X²
688  54   )
689  42  STO
690  04   04
691  95   =
692  32  X:T
693  43  RCL     1560
694  00   00
695  65   ×
696  43  RCL
697  02   02
698  65   ×
699  53   (
700   53   (
701   43  RCL
702   03   03
703   94  +/-
704   55   ÷
705   43  RCL
706   01   01
707   54   )
708   22  INV
709   23  LNX
710   85   +
711   01   1
712   54   )
713   65   ×
714   53   (
715   43  RCL
716   03   03
717   55   ÷
718   02   2
719   75   -
720   01   1
721   02   2
722   54   )
723   22  INV
724   23  LNX
725   55   ÷
726   43  RCL
727   04   04
728   95   =
729   71  SBR     1570,80
730   07   07
731   95   95
732   61  GTO
733   03   03
734   52   52
735   43  RCL     1640,60
736   05   05
737   75   -
738   43  RCL
739   18   18
740   75   -
741   32  X:T
742   01   1
743   02   2
744   65   ×
745   53   (
746   32  X:T
747   69  OP
748   10   10
749   85   +
```

```
750   32  X:T
751   01   1
752   54   )
753   65   ×
754   32  X:T
755   50  I×I
756   95   =
757   55   ÷
758   02   2
759   95   =
760   22  INV     1680
761   23  LNX
762   65   ×
763   53   (
764   53   (
765   43  RCL
766   03   03
767   94  +/-
768   55   ÷
769   43  RCL
770   01   01
771   54   )
772   22  INV
773   23  LNX
774   85   +
775   01   1
776   54   )
777   65   ×
778   43  RCL
779   02   02
780   65   ×
781   43  RCL
782   00   00
783   55   ÷
784   53   (
785   01   1
786   85   +
787   43  RCL
788   02   02
789   33  X²
790   95   =
791   61  GTO
792   03   03
793   52   52
794   22  INV     MIN/MAX
795   77   GE     SUBROUTINE
796   07   07
797   99   99
798   32  X:T
799   92  RTN
```

APPENDIX C

PROGRAM LOGIC MODIFICATIONS

The following program logic changes were made to the BASIC version of MINIMUF-3.5 to minimize program storage requirements:

(1) The computation of M9 at lines 1300-1330 and 1430-1460 is independent of the main loop and was moved to the beginning of the program, immediately following the calculation of G1 and K5.

(2) The loop index computation at line 1070 was separated into a computation of a new variable, KHOP, which is either 1 or 2, and a follow-on computation of K1 from KHOP as the first item within the loop.

(3) The computation of G8 at lines 1530 and 1650 is common to both legs of the preceeding test for (T5-T4)(T-T5), and has been moved ahead of that test.

(4) The test at line 1470 serves to reverse the sense of the following tests at lines 1480 and 1500. This logic has been combined into a single test on (T5-T4)(T-T5) with a weighting factor of 1 or -1 to reverse the sense of that test.

(5) The computation at line 1360 was simplified to the arcsine by way of trigonometric identity.

(6) The MUF limit established at line 1730 was changed to 50 vice 32 to accomodate high solar flux densities.

(7) Throughout the program, explicit calculation and storage of variables that are used only once in following statements has been eliminated to conserve on data register requirements.

APPENDIX D

PROGRAM OPERATING INSTRUCTIONS

The following instructions must be followed to operate the TI-59 version of MINIMUF-3.5:

(1) Repartition the calculator for 800 program steps and 20 data registers by pressing 2/OP/17.

(2) Load the 4 memory banks from program cards (2) or by entering program keystrokes with the calculator. in the LRN mode.

(3) Enter input data as follows:

(a) Transmitter North Latitude in decimal degrees in R12 (range -90 degrees to 90 degrees)

(b) Transmitter West Longtitude in decimal degrees in R13 (range 0 to 360 degrees)

(c) Receiver North latitude in decimal degrees in R14 (range -90 to 90 degrees)

(d) Receiver West Longtitude in decimal degrees in R15 (range 0 to 360 degrees)

(e) Month in R16 (range 1 to 12)

(f) Day in R17 (range 1 to 31)

(g) Sunspot Number in R19 (range - positive number)

(4) Enter Time in X-register (range 0 to 24 decimal hours)

(5) Press A

(6) If a printer is attached, the input time is echoed, followed by the answer (MUF) after 50 seconds for single-hop and 100 seconds for two-hop predictions.

(7) The answer is displayed in the X-register when the program halts.

(8) All input quantities remain undisturbed in R12 thru R19 (time is stored by the program in R18). Another MUF for a different time can be computed directly by repeating steps (4) and (5).

APPENDIX E

TEST CASE

The test case that follows was provided in the NOSC report on MINIMUF-3.5. The actual printer listing of input and program output is included.

```
CONTENTS        REG
   21.          12      (L1)
  156.          13      (W1)
   38.          14      (L2)
  122.          15      (W2)
   10.          16      (MO)
   17.          17      (D6)
    0.          18
  110.          19      (S9)
```

INPUT

```
 0.0 (Time)
36.3 (MUF)
 1.0
35.0 (etc)
 2.0
32.9
 3.0
29.9
 4.0
25.0
 5.0
22.8
 6.0
20.9
 7.0
19.3
 8.0
18.0
 9.0
16.9
10.0
16.0
11.0
15.2
12.0
14.6
13.0
14.1
14.0
13.7
15.0
21.0
16.0
27.6
17.0
31.5
18.0
34.0
19.0
35.6
20.0
36.7
21.0
37.3
22.0
37.5
23.0
37.1
```

OUTPUT

APPENDIX F

TI-59 CUSTOM MODULES

The following points of contact are provided for the design and manufacture of TI-59 custom modules. Both Texas Instruments and Horizons Technology (contracting with TI) provide software, emulator, and consulting support for the design and production of custom modules. Costs quoted at this time are approximately $12,000 for a minimum order of 250 modules. This includes emulator support and manufacture, but does not include software consulting. Cost reduction through quantity is available.

Fred Wilke
TI-59 Custom Module Division
Texas Instruments
Lubbock, TX
(806) 741-3240

Robert Kruger
Horizons Technology, Inc.
7830 Clairemont Mesa Boulevard
San Diego, CA 92111
(714) 292-8331

LIST OF REFERENCES

1. Rose, R.B. and Martin, J.N., "MINIMUF-3.5, Improved Version of MINIMUF-3, A Simplified HF MUF Prediction Algorithm", Technical Document 201, Naval Ocean Systems Center, San Diego, 26 October 1978.

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